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IMAGE FORMING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a technique for correcting the inclination of each individual color image in an electrophotographic color image forming
5 apparatus having a plurality of photosensitive bodies.

In an electrophotographic conventional image forming apparatus, an electrophotographic photosensitive body, serving as an image-carrying member, is charged by a static charger, the charged
10 electrophotographic photosensitive body is irradiated with light in accordance with image information to form a latent image, which is then developed by a developing device, and the developed toner image is transferred to a paper sheet or the like to form the intended image.

15 On the other hand, as color imaging techniques have become available, there has been proposed a color image forming apparatus having a plurality of image forming stations arranged in tandem, each of which performs the above-cited image forming
20 process to form a cyan image, a magenta image, a yellow image and, preferably, a black image on the respective image-carrying members, and these individual color images are transferred in their respective transfer positions to a paper sheet to form a full color image.
25 Such a color image forming apparatus of the tandem

arrangement is advantageous for high-speed operation because it has an image forming section for each individual color.

However, this apparatus involves a problem of difficulty in achieving satisfactory positional registration of the individual images formed by different image forming sections. There arise deviations in the angle of the rotational axis of the electrophotographic photosensitive body drum in each image forming station and in that of the fitting of the scanning optical system, leading to positional misregistrations in oblique directions (hereinafter to be collectively referred to as skews), because positional differences among the formed images of four individual colors transferred to a paper sheet or the like eventually emerge as positional misregistrations or variances in tint. FIGS. 6A and 6B show skewed images, FIG. 6A showing an image skewed upward, and FIG. 6B one skewed downward.

FIG. 7 illustrates a configuration of tone pattern correction according to the prior art.

First, skew compensating means 23 carries out skew compensation, on the basis of a preset quantity of deviation due to skewing, in accordance with shift points given from shift point setting means 24 which sets the shift points of data and a shifting direction from direction setting means 26 which indicates the direction in which the skew has arisen. The procedure

of skew compensation will be described below.

FIGS. 8A and 8B are block diagrams of the skew compensating means. It takes out an image from data accumulating means 35 according to the shift

5 points and shift direction, both referred to above, and data correcting means 36 shifts at each shift point in the correcting direction line by line to output an image having no apparent inclination. FIGS. 9A and 9B show skew-compensated images, FIG. 9A showing the

10 result of skew compensation of the image inclined upward to the right, and FIG. 9B, that of skew compensation of the image inclined downward to the right.

However, shifting of the image line by line

15 in the skew compensation procedure invites a new problem of tone disruption. To cope with this problem, tone processing means 34 carries out tone pattern correction by shifting a tone pattern stored in a tone pattern table according to the shift points and

20 shifting direction, both referred to above. This tone pattern correction will be described below.

FIG. 10 illustrates the configuration of tone processing means according to the prior art. Pattern data acquiring means 37 successively takes out pattern

25 data from the tone pattern table 33 in accordance with a table address initial value from table address initial value setting means 28. Binarizing means 32 compares multi-value data and the tone pattern and, if

the multi-value data are found greater than the tone pattern, outputs print dots or, if not, outputs binary data as non-print dots. Hereupon, a point counter 30 counts up every time an image is binarized and, when

5 the count becomes identical with a preset shift point offset from shift point offset setting means 29, the counter is reset. The pattern data acquiring means 37 shifts the tone pattern table by one column at a time in a direction reverse to the aforementioned shifting

10 direction, and takes out pattern data. After that, the point counter 30 counts up every time an image is binarized, and resets itself when the count becomes identical with the shift point offset; the pattern data acquiring means 37 shifts the tone pattern table by one

15 column at a time in the direction reverse to the aforementioned shifting direction, and takes out pattern data, resulting in improvement of the tone disruption.

Hereupon, the table address initial value and

20 the shift point offset value in a case where the correcting direction of the tone pattern is upward or downward will be described with reference to FIG. 11. The tone pattern is an image pattern consisting of tile-like segments pasted all over a paper sheet with

25 reference to the origin. Since the print starting position of the image itself is also determined with reference to the origin, the position of the tone pattern in the print starting position is determined on

a relative basis. This position of the tone pattern is supposed to be the table address initial value. Since the shift point, too, references the origin, the print starting position and the number of picture elements

5 until the next shift point are determined. This number of picture elements is supposed to be the shift point offset value.

FIG. 12 illustrates the image after the tone pattern correction.

10 However, in the conventional configuration described above, even if an image forming apparatus which rotates binary data corrects the tone pattern by tone processing, if the image is rotated after that processing and the rotated image undergoes skew

15 compensation, the direction of tone pattern correction will be distorted with respect to the direction of skew compensation with the result that the disruption in tone pattern cannot be remedied.

SUMMARY OF THE INVENTION

20 In order to solve the above-mentioned problems, the present invention provides a configuration comprising tone processing means for converting multi-value input data into binary areal tones; a tone pattern table for storing tone patterns

25 to be used by the tone processing means; rotating means for rotating the output of the tone processing means; skew compensating means for compensating for any skew

caused by an image forming apparatus upon the output of
the rotating means; shift point setting means for
setting a skew compensating position; shifting
direction setting means for setting a shifting

5   direction according to a skew direction; and rotating
direction setting means for setting a rotating
direction, wherein the tone pattern can be corrected
even if the binary data are rotated. This
configuration enables images of high print quality to

10   be obtained by performing appropriate tone pattern
correction in advance against the disruption of
gradation resulting from the compensation for skews.

BRIEF DESCRIPTION OF THE DRAWINGS

         FIG. 1 shows an arrangement of a color image

15   forming apparatus, which is a first embodiment of the
present invention;

         FIG. 2 shows an arrangement of the tone
pattern correction against rotation in the first
embodiment of the present invention;

20   FIG. 3 shows an arrangement of tone
processing means in the first embodiment of the present
invention;

         FIG. 4 shows an arrangement of a tone pattern
table;

25   FIG. 5 shows a shifting operation of a
shiftable tone pattern table in a second embodiment of
the present invention;

FIG. 6 shows skewed images;

FIG. 7 shows an arrangement of the tone pattern correction according to the prior art;

FIG. 8 shows a block diagram of skew compensating means;

FIG. 9 shows skew-compensated images;

FIG. 10 shows an arrangement of tone processing means according to the prior art;

FIG. 11 shows a table address initial value and a shift point offset value in a case where the correcting direction of the tone pattern is upward or downward; and

FIG. 12 shows an image after tone pattern correction.

PREFERRED EMBODIMENTS OF THE INVENTION

(First Embodiment)

A first embodiment of the present invention will be described below with reference to FIGS. 1 to 4. FIG. 1 shows an arrangement of a color image forming apparatus, which is a first embodiment of the present invention.

First of all, the process of obtaining a color image will be described with reference to FIG. 1.

Referring to FIG. 1, in a color image forming apparatus, there are arranged four image forming stations 1a, 1b, 1c and 1d, and the image forming stations 1a, 1b, 1c and 1d respectively have

electrophotographic photosensitive drums 2a, 2b, 2c and
2d as image carrying members, around which there are
respectively arranged dedicated charging means 3a, 3b,
3c and 3d, developing means 4a, 4b, 4c and 4d, cleaning
5 means 5a, 5b, 5c and 5d, exposing means 6a, 6b, 6c and
6d of a scanning optical system for irradiating the
respective electrophotographic photosensitive drums
with light corresponding to image information, and
transferers 8a, 8b, 8c and 8d in transferring means 7.

10   The image forming stations 1a, 1b, 1c and 1d
here are where yellow, magenta, cyan and black images
are formed, and each light 9a, 9b, 9c and 9d
corresponding to the yellow, magenta, cyan and black
images are outputted from the exposing means 6a, 6b, 6c
15 and 6d, respectively. In a mode of passing the image
forming stations 1a, 1b, 1c and 1d, an intermediate
transfer belt 12 of the endless type, supported by
rollers 10 and 11, is arranged underneath the
electrophotographic photosensitive drum 2a, 2b, 2c and
20 2d, and moves in a direction of arrow A. The
operations of these elements are controlled by control
means.

        Paper sheets 16 stacked in a paper cassette
15 are fed by a feed roller 17, and discharged into a
25 paper tray (not shown) via a paper sheet transfer
roller 18 and fixing means 19.

        In the above-mentioned arrangement, after a
latent image of the black color component of the image

information is first formed on the electrophotographic
photosensitive drum 2d by such known
electrophotographic processing means as the charging
means 3d and the exposing means 6d of the image forming

5   station 1d, it is made visible as a black toner image
out of a developer containing a black toner by the
developing means 4d, and the black toner image is
transferred by the transferer 8d onto the intermediate
transfer belt 12.

10   On the other hand, while the black toner
image is being transferred to the intermediate transfer
belt 12, the image forming station 1c forms a latent
image of the cyan color component, and the developing
means 4c provides a cyan toner image out of a cyan

15   toner. The cyan toner image is transferred to the
transferer 8c and superposed over the black toner image
earlier transferred onto the intermediate transfer belt
12.

           Hereafter, a magenta toner image and a yellow

20   toner image are formed by similar methods. When the
superposition of the toner images of the four colors on
the intermediate transfer belt 12 is completed, the
toner images of the four colors are collectively
transferred by the paper sheet transfer roller 18 onto

25   the paper sheet 16 fed from the paper cassette 15 by
the feed roller 17, and thermally fixed by the fixing
means 19 to give a full color image on the paper sheet
16. The electrophotographic photosensitive drum 2a,

2b, 2c and 2d after the completion of the transfer are
cleared of the residual toner by the cleaning means 5a,
5b, 5c and 5d to be readied for the next round of image
forming, and the printing operation is completed.

5   While a color image can be obtained in this
manner, there arises a misregistration between each
image forming station and the scanning optical system,
and each color is skewed.

        FIG. 2 shows an arrangement of the tone
10 pattern correction against rotation in the fist
embodiment of the present invention. The arrangement
comprises tone processing means 21 for converting
multi-value input data into binary areal tones; a tone
pattern table 20 for storing tone patterns to be used
15 by the tone processing means; rotating means 22 for
rotating the output of the tone processing means; skew
compensating means 23 for compensating for any skew
caused by an image forming apparatus upon the output of
the rotating means; shift point setting means 24 for
20 setting a skew compensating position; shifting
direction setting means 26 for setting a shifting
direction according to a skew direction; and rotating
direction setting means 25 for setting a rotating
direction.

25   Since each means has its own skew, when each
means is assembled and adjusted, the skew is measured
according to its output image to assess the quantity of
misregistration, and the skew is compensated for by the

skew compensating means 23. Further description of
this skew compensation is dispensed with, because it is
no different from the prior art. Further, as skew
compensation gives rise to a disruption in tone pattern
5   attributable to a gap of one line, the tone pattern is
corrected in advance by the tone processing means 21.

The tone pattern correction according to the
present invention will be described below.

FIG. 3 shows an arrangement of the tone
10 processing means in the first embodiment of the present
invention with particular reference to the arrangement
of the tone pattern correction. Pattern correcting
direction determining means 27 determines in which
direction – upward, downward, leftward or rightward –
15 the tone pattern is to be shifted according to the
image rotating direction made known by the rotating
direction setting means 25 and the shifting direction
(upward or downward toward the right) made known by the
shifting direction setting means 26. More
20 specifically, where the rotational angle is 0 degree,
if the skewing direction is upward toward the right,
the direction of tone pattern correction will be
downward or, if the skewing direction is downward
toward the right, the direction of tone pattern
25 correction will be upward. Where the rotational angle
is 90 degrees, if the skewing direction is upward
toward the right, the direction of tone pattern
correction will be leftward or, if the skewing

direction is downward toward the right, the direction
of tone pattern correction will be rightward. Where
the rotational angle is 180 degrees, if the skewing
direction is upward toward the right, the direction of
5   tone pattern correction will be upward or, if the
skewing direction is downward toward the right, the
direction of tone pattern correction will be downward.
Or where the rotational angle is 270 degrees, if the
skewing direction is upward toward the right, the
10 direction of tone pattern correction will be rightward
or, if the skewing direction is downward toward the
right, the direction of tone pattern correction will be
leftward.

The tone pattern table 20 stores tone
15 patterns in registers each consisting of an external
memory or hardware. In this embodiment, pattern data
are supposed to be stored in a block of (rows, columns)
= (m, n) as the configuration of the tone pattern table
in FIG. 4 shows. Sets of pattern data are usually
20 stored consecutively to facilitate their taking out.
Pattern data are taken according to the table address.

Rotation-responsive pattern acquiring means
31 takes out a tone pattern from the tone pattern table
20 on the basis of the direction of tone pattern
25 correction from the pattern correcting direction
determining means 27, table address initial values
(rows, columns) = (a, b) determined from the printing
position of the image on the printing paper and preset

in the table address initial value setting means and a
shift point offset set in the shift point offset
setting means.

For a more specific description, first a case
5   in which the angle of rotation is 90 degrees, the
skewing direction is upward toward the right and the
direction of tone pattern correction is leftward will
be referred to.

As a basic operation, in the processing of
10 the first line of the image, pattern data are taken out
of the table address initial values (a, b). Every time
a set of pattern data is taken out, only the address
value in the column direction is counted up by +1, and
sets of data are taken out successively. When the
15 processing has advanced to a point where the address
value in the column direction has become equal to m,
the address value in the column direction is returned
to the beginning to make the table address (0, b).
Then, sets of pattern data are again taken out while
20 counting up the address value by +1 each time. This
processing is repeated over the whole line.

When the processing of the first line is
completed, the second line begins to be processed. The
table address then is (a, b+1), with +1 added to the
25 table address initial value in the row direction. Sets
of pattern data are taken out while varying the address
in the row direction as in the processing of the first
line. Processing of the third and subsequent lines

will be carried out in the same manner. When the line-
by-line processing has advanced to a point where the
address in the row direction has become equal to n, the
address in the row direction in the table address on
5 the next line is returned to the beginning to reduce
the address value in the row direction to 0.

For tone pattern correction, the shift point
offset value is set in the processing of the first line
as the initial value of the point counter 30. For the
10 second and subsequent lines, the point counter 30 is
counted up by +1 every time the processing advances to
the next line. When the line-by-line processing has
advanced to a point where the count of the point
counter has become equal to the shift point value, 1 is
15 subtracted from the address in the column direction of
the table address of the line, determined by the above-
described basic operation, if the address is not 0 or,
if it is 0, the address in the column direction is
converted to m. Then, the point counter 30 is cleared
20 at the same time. Similar processing is repeated for
the subsequent lines.

Next will be described a case in which the
angle of rotation is 90 degrees, the skewing direction
is downward toward the right and the direction of tone
25 pattern correction is rightward.

As a basic operation, in the processing of
the first line of the image, pattern data are taken out
of the table address initial values (a, b). Every time

a set of pattern data is taken out, only the address
value in the column direction is counted up by +1, and
sets of pattern data are taken out successively. When
the processing has advanced to a point where has become
5   equal to m, the address value in the column direction
is returned to the beginning to make the table address
(0, b). Then, sets of pattern data are again taken out
while counting up the address value by +1 each time.
This processing is repeated over the whole line.

10   When the processing of the first line is
completed, the second line begins to be processed. The
table address then is (a, b+1), with +1 added to the
table address initial value in the row direction. Sets
of pattern data are taken out while varying the address
15 in the column direction as in the processing of the
first line. Processing of the third and subsequent
lines will be carried out in the same manner. When the
line-by-line processing has advanced to a point where
the address in the row direction has become equal to n,
20 the address value in the row direction in the table
address on the next line is returned to the beginning
to reduce the address value in the row direction to 0.

            For tone pattern correction, the shift point
offset value is set in the processing of the first line
25 as the initial value of the point counter 30. For the
second and subsequent lines, the point counter 30 is
counted up by +1 every time the processing advances to
the next line. When the line-by-line processing has

advanced to a point where the count of the point

counter has become equal to the shift point value, +1

is added to the address in the column direction of the

table address of the line, determined by the above-

5 described basic operation, if the address is not m or,

if it is m, the address in the column direction is

converted to 0. Then, the point counter 30 is cleared

at the same time. Similar processing is repeated for

the subsequent lines.

10   Next will be described a case in which the

angle of rotation is 180 degrees, the skewing direction

is upward toward the right and the direction of tone

pattern correction is upward.

        As a basic operation, in the processing of

15 the first line of the image, pattern data are taken out

of the table address initial values (a, b). Every time

a set of pattern data is taken out, only the address

value in the column direction is counted up by +1, and

sets of data are taken out successively. When the

20 processing has advanced to a point where has become

equal to m, the address value in the column direction

is returned to the beginning to make the table address

(0, b). Then, sets of pattern data are again taken out

while counting up the address value by +1 each time.

25 This processing is repeated over the whole line.

        For tone pattern correction, the shift point

offset value is set in the processing of the first line

as the initial value of the point counter 30. The

point counter 30 is counted up by +1 at every time of
image processing in the line direction. When the
processing has advanced to a point where the count of
the point counter has become equal to the shift point

5   value, 1 is subtracted from the address in the column
direction of the table address of the line if the row
address, determined by the above-described basic
operation, is not 0 or, if it is 0, the address in the
row direction is converted to n. Then, the point

10   counter 30 is cleared at the same time. Similar
processing is repeated for the subsequent lines.

        When the processing of the first line is
completed, the second line begins to be processed. The
table address then is (a, b+1), with +1 added to the

15   table address initial value in the row direction. Sets
of pattern data are taken out while varying the address
in the column direction as in the processing of the
first line. Processing of the third and subsequent
lines will be carried out in the same manner. When the

20   line-by-line processing has advanced to a point where
the address in the row direction has become equal to n,
the address value in the row direction in the table
address on the next line is returned to the beginning
to reduce the address value in the row direction to 0.

25   Next will be described a case in which the
angle of rotation is 180 degrees, the skewing direction
is downward toward the right and the direction of tone
pattern correction is downward.

As a basic operation, in the processing of the first line of the image, pattern data are taken out of the table address initial values (a, b). Every time a set of pattern data is taken out, only the address value in the column direction is counted up by +1, and sets of data are taken out successively. When the processing has advanced to a point where has become equal to m, the address value in the column direction is returned to the beginning to make the table address (0, b). Then, sets of pattern data are again taken out while counting up the address value by +1 each time. This processing is repeated over the whole line.

For tone pattern correction, the shift point offset value is set in the processing of the first line as the initial value of the point counter 30. The point counter 30 is counted up by +1 at every time of image processing in the line direction. When the processing has advanced to a point where the count of the point counter has become equal to the shift point value, +1 is added to the address in the column direction of the table address of the line if the row address, determined by the above-described basic operation, is not n or, if it is n, the address in the row direction is converted to 0. Then, the point counter 30 is cleared at the same time. Similar processing is repeated for the subsequent lines.

When the processing of the first line is completed, the second line begins to be processed. The

table address then is (a, b+1), with +1 added to the
table address initial value in the row direction. Sets
of pattern data are taken out while varying the address
in the column direction as in the processing of the
5   first line. Processing of the third and subsequent
lines will be carried out in the same manner. When the
line-by-line processing has advanced to a point where
the address in the row direction has become equal to n,
the address value in the row direction in the table
10 address on the next line is returned to the beginning
to reduce the address value in the row direction to 0.

     Since other combinations of the angle of
rotation and the skewing direction fit some case or
another of processing so far described, their
15 description is dispensed with.

     Pattern data are taken out while varying the
table address successively as described above. Each
set of pattern data taken out is outputted to the
binarizing means 32, and the image is binarized through
20 comparison with its multi-value data.

     The binarized image is rotated by the
rotating means 22 in a direction of rotation preset by
the rotating direction setting means 25, and outputted
to the skew compensating means 23. Description of the
25 rotation processing is dispensed with because it is
done by a known technique.

(Second Embodiment)

     A second embodiment of the present invention

will now be described with reference to FIG. 5. FIG. 5
shows a shifting operation of a shiftable tone pattern
table in the second embodiment of the present
invention. In this second embodiment, the tone pattern

5   table 20 is supposed to be registers of a 6 × 3 size
consisting of hardware. By varying the set point of
pattern data according to the direction of tone pattern
correction determined by the pattern correcting
direction determining means 27, the tone pattern is

10 switched. To be more specific, the processing will be
described with reference to a case in which the
direction of tone pattern correction is leftward. The
pattern is shifted by shifting leftward all the pattern
data set in the pattern table, as illustrated in FIG.

15 5B, when the point counter value has become equal to
the shift point value while carrying on processing in
the row direction of each line. At this time, pattern
data on the leftmost register are stored into the
rightmost register. Tone pattern correction in any

20 other direction is accomplished by shifting pattern
data. In this processing to shift pattern data, the
rotation-responsive pattern acquiring means 31 does not
convert any table address by tone pattern correction.

        As hitherto described, according to the

25 present invention, it is possible to improve any
disruption in tone pattern even if an image is rotated
after binarization and subjected to skew compensation,
because the disruption due to skew compensation is

adjusted in advance with consideration given to the
direction of image rotation and that of skew
compensation during the binarization. Since no
particular alternation in mechanism is required, a
5   color image forming apparatus of high print quality can
be achieved with no extra cost.